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EFFECT OF IGNITER GASES ON WEAR-REDUCING ADDITIVE IN THE 155mm XM201E2 PROPELLING CHARGE

J. Richard Ward
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April 1978

US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
BALLISTIC RESEARCH LABORATORY
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) (meg)

The wear-reducing liner in the base-ignited XM201E2 charge failed to reduce the erosivity of the XM201E2 charge. When the clean-burning igniter (CBI) in the XM201E2 charge was replaced by black powder, the barrel life of 155mm howitzers firing the modified XM201E2 charge increased to 3,500 rounds from 1,000 rounds with CBI.

Considerable gun barrel heating by igniter gases was observed during experiments conducted to ascertain why the wear rate of cannon firing (Cont'd) over

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20. Abstract (Cont'd)

XM201E2 charges was unexpectedly high. One explanation for the failure of the TiO_2/wax additive with CBI might be physical changes in the liner during the preheating stage before the propellant ignited. To test this hypothesis, XM201E2 charges were loaded with inert propellant and fired in a closed chamber simulating the chamber configurations of the M185 and M199 howitzers. Examination after firing with each igniter showed no physical damage to the TiO_2/wax liner.

It was also noted that the black-powder ignited XM201E2 charge moved 5 cm closer to the projectile base during igniter functioning, while the CBI-ignited charge moved 2.5 cm. Whether this movement is important regarding additive effectiveness cannot be ascertained from this experiment.

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I. INTRODUCTION

The XM201E2 is a 155mm propelling charge that was designed to fire zones 6 and 7 from the new extended-range self-propelled and towed howitzers. The XM201E2 charge was developed to replace the M119 propelling charge which fires only zone 7. A comparison between the two propelling charges is listed in Table I. The two chief differences are the propellant choice and the ignition mode. The XM201E2 charge uses triple-base M30A1 propellant which has higher impetus than the single-base M6 propellant in the M119 charge. Less propellant is needed for comparable performance with the use of the higher-impetus M30A1; this also allowed the charge designer sufficient free volume in the chamber to eliminate placing a center-core igniter in the XM201E2 charge. This makes the XM201E2 charge easier to load, pack, and assemble so that the XM201E2 charge costs twelve dollars less to produce. The only performance penalty is the higher erosivity of the M30A1 propellant. To offset this, a TiO_2/wax liner was included in the XM201E2 propelling charge, so that cannons firing the XM201E2 charge would achieve the same 5,000 round useful life as when firing the M119 charge.

TABLE I. PHYSICAL COMPARISON OF THE XM201E2 AND THE M119 CHARGES

	M119	XM201E2
Charge Diameter, cm	15.8 (16.5 max)	12.7 (13.0 max)
Charge Length, cm	63.5 (66.0 max)	74.9
Igniter	Centercore	Base
Propellant	M6	M30A1
Propellant Flame Temperature, K	2570	3007
Propellant Weight, kg	9.30	7.80
Wear-Reducing Jacket, g	None	27 (TiO_2/wax)

The XM201E2 failed to meet the 5,000 round requirement[1]. The tube life was only 1,000 rounds. This was startling since the zone 8, M203 charge, contained 2.1 kg more M30 propellant than the XM201E2 charge, yet eroded 155mm cannons slower than did the XM201E2 charge[2]. This suggested that the wear-reducing additive in the XM201E2 charge was ineffective. This was confirmed using newly-developed techniques to assess the effectiveness of wear-reducing additives in a few shots by measuring heat input to the barrel or the erosion rate of metal inserts[3,4].

1. J.A. Demaree, "155mm M185 Tube Wear Test of Charge Propelling XM201", Jefferson Proving Ground Test Report No. JPG-76-601, June 76.
2. YPG Firing Report 13703, 15 Mar 77.
3. J.R. Ward and T.L. Brosseau, "Effect of Wear-Reducing Additives on Heat Transfer into the 155mm M185 Cannon", BRL MR No. 2730, Feb 77. (AD #A037374)
4. F.A. Varssallo, "An Evaluation of Heat Transfer and Erosion in the 155mm M185 Cannon", Calspan Technical Report No. VL-5337-D-1, Jul 76.

It was further demonstrated that the TiO_2/wax additive was effective when the ignition delay of the XM201E2 charge was shortened by replacing the clean-burning igniter with some black powder. Full-scale wear tests confirmed these conclusions[5,6], although the wear life from firing the redesigned XM201E2 charge still failed to reach the required 5,000 rounds which led to failure of the XM201E2 charge to reach type-classification.

During the screening tests, it was observed that the barrel was heated by the igniter gases. This "pre-heating" was considerably smaller when the ignition delay was shortened with black powder. One explanation for the failure of the TiO_2/wax additive to reduce erosion with the clean-burning igniter could be physical degradation of the liner during the pre-heating phase. In order to test this possibility, inert-loaded XM201E2 charges were fired with clean-burning and black powder igniters in a closed chamber simulating the chamber of a 155mm howitzer.

II. EXPERIMENTAL

The M30A1 propellant in three XM201E2 charges was replaced with an equivalent mass of inert propellant. An 85 g black powder igniter from an M4A1 charge replaced the 71 g clean-burning igniter on one of the three inert loaded charges.

The inert charges were fired in a closed chamber with dimensions closely conforming to the chamber dimensions in the actual howitzer. An earlier report describes the laboratory simulator in detail[7]. Kistler 601B gauges measured the pressure produced in the chamber by the igniter gases.

After firing the igniter, the distance the propelling charge moved from the initial 2.5 cm stand-off was recorded. The charge was removed from the laboratory simulator and inspected.

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5. *P.V. Tague, "DTII of the XM198, 155mm Howitzer - XM199E9 Tube Wear Investigation", Yuma Proving Ground Firing Report No. 13702, 1976.*

6. *M. Kahn, "First Letter Report of Development Test II: Wear Phase of Propelling Charge, 155mm XM201E5, TECOM Project No. 2-MU-004-201-008", Materiel Testing Directorate, Aberdeen Proving Ground, Maryland, Jul 77.*

7. *K.J. White, R.A. Hartman, I.W. May, and J.R. Kelso, "Experimental Investigation of Ignition Train Systems for Bagged Charges", 14th JANNAF Combustion Meeting, Colorado Springs, CO, Aug 77.*

III. RESULTS AND DISCUSSION

Figure 1 compares the TiO_2/wax liner taken from the zone 7 increment after firing with a liner taken from an XM201E2 charge prior to firing. Clearly, the igniter gases from either the clean-burning igniter or the black powder do not melt or damage the TiO_2/wax liner in any fashion. The liner from the clean-burning ignited charge looks even more like the original TiO_2/wax liner than the liner from the black-powder ignited charge. This experiment shows that the "preheating" seen in the earlier tests with thermocouples mounted in the barrel does not damage the TiO_2/wax liner in the standard XM201E2 charge which might have accounted for the failure of the TiO_2/wax liner to exert influence on the erosivity of the propellant gases. These results do point to the complex hydrodynamics controlling the action of the wear-reducing liner, since the longer ignition delay of the clean-burning igniter somehow leads to failure of the liner to reduce erosion.

The effect of the black powder on ignition delay is evident in the time to peak chamber pressure given below:

Igniter	P_{max}, MPa	Time to P_{max}, ms
CBI - Test 1	2.9	140
CBI - Test 2	2.6	180
BP	1.8	64

Figures 2 through 4 depict the pressure *vs* time for each charge fired.

It was also noted the charge ignited with black powder moved 5 cm closer to the end of the chamber corresponding to the projectile. The charges ignited with the clean-burning igniter moved only 2.5 cm closer to the end where the projectile would have been located. Whether this difference contributes to the black-powder ignited charge's lower erosion rate cannot be inferred from this experiment.

Figure 5 and 6 depict the inert-loaded charges after igniter firing. The zone 7 increment from the black-powder ignited charge had been removed for inspection prior to making the photograph.

IV. CONCLUSIONS

1. The TiO_2/wax liner in the XM201E2 is not affected during ignition. The failure of the TiO_2/wax liner to exert any influence on the erosivity of the XM201E2 charge must be ascribed to something other than liner degradation before the propellant ignites.

2. The inert-loaded XM201E2 charge moved 5 cm towards the projectile base and 2.5 cm toward the projectile base when fired with black powder and clean-burning igniters, respectively.

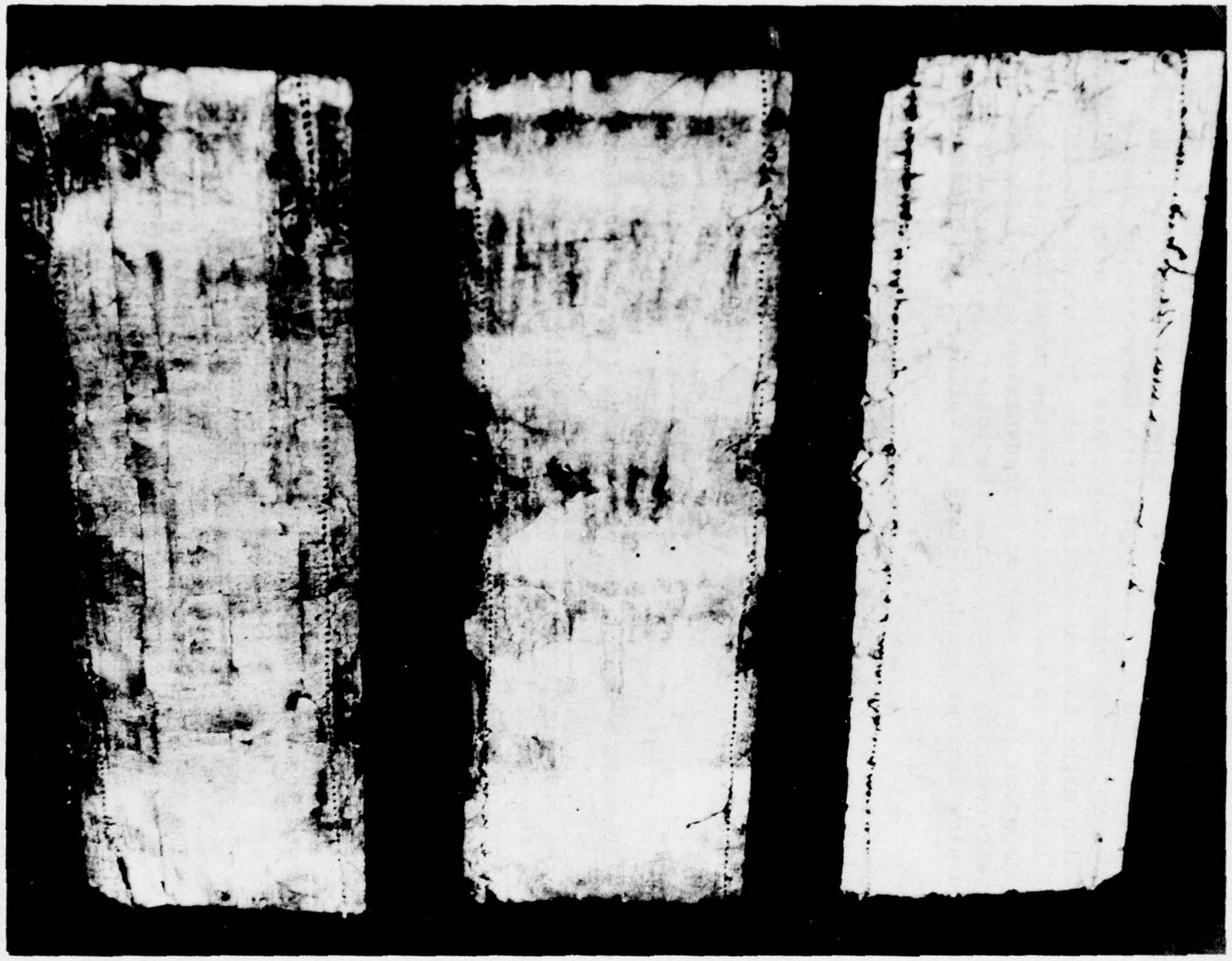

Figure 1. Zone 7 Increment TiO_2/wax Liner Before Firing (top), Exposed to Clean-Burning Igniter (middle), Exposed to Black Powder (bottom).

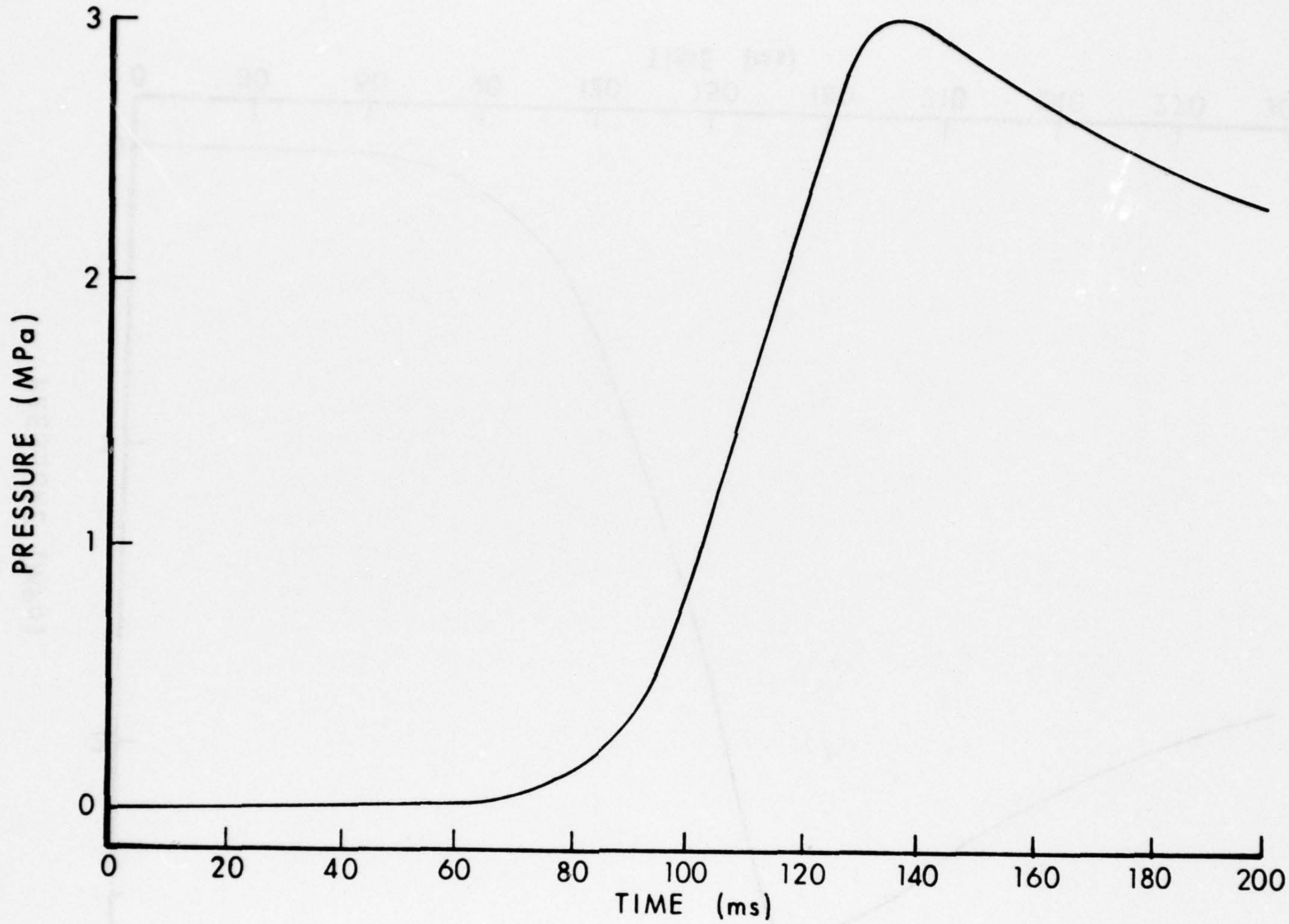

Figure 2. Pressure vs Time - CBI Test 1

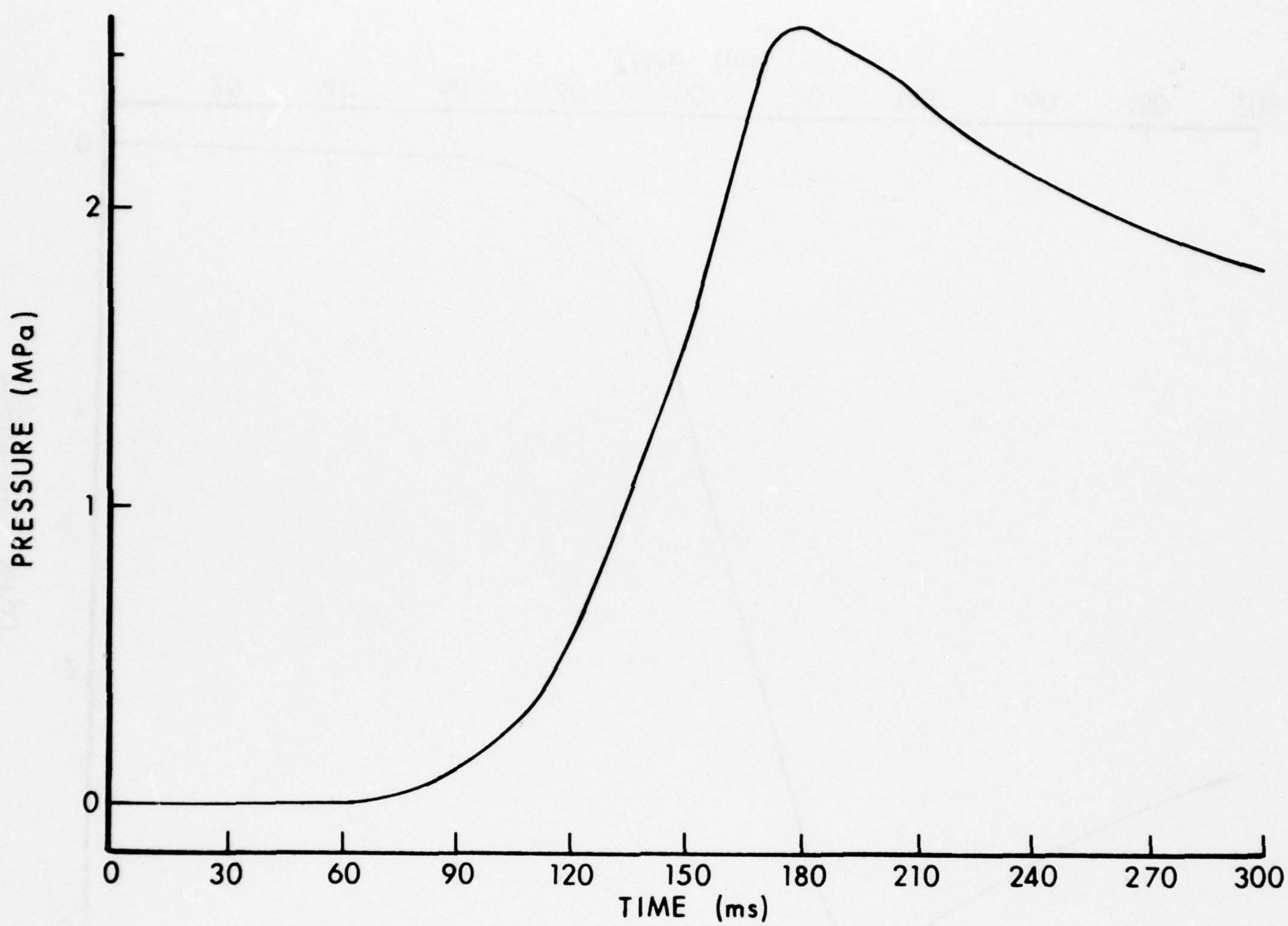

Figure 3. Pressure vs Time - CBI Test 2

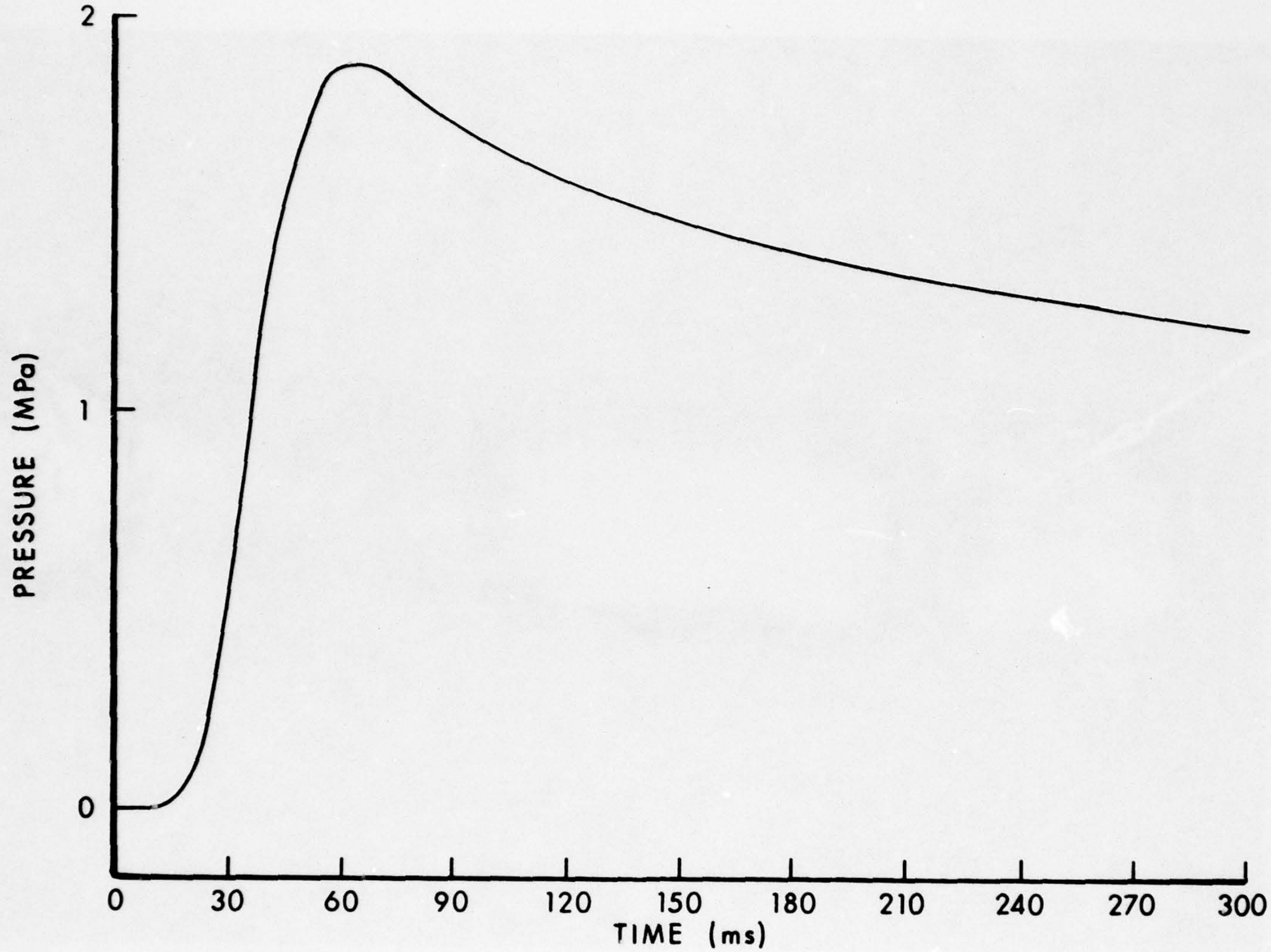

Figure 4. Pressure vs Time - BP Igniter

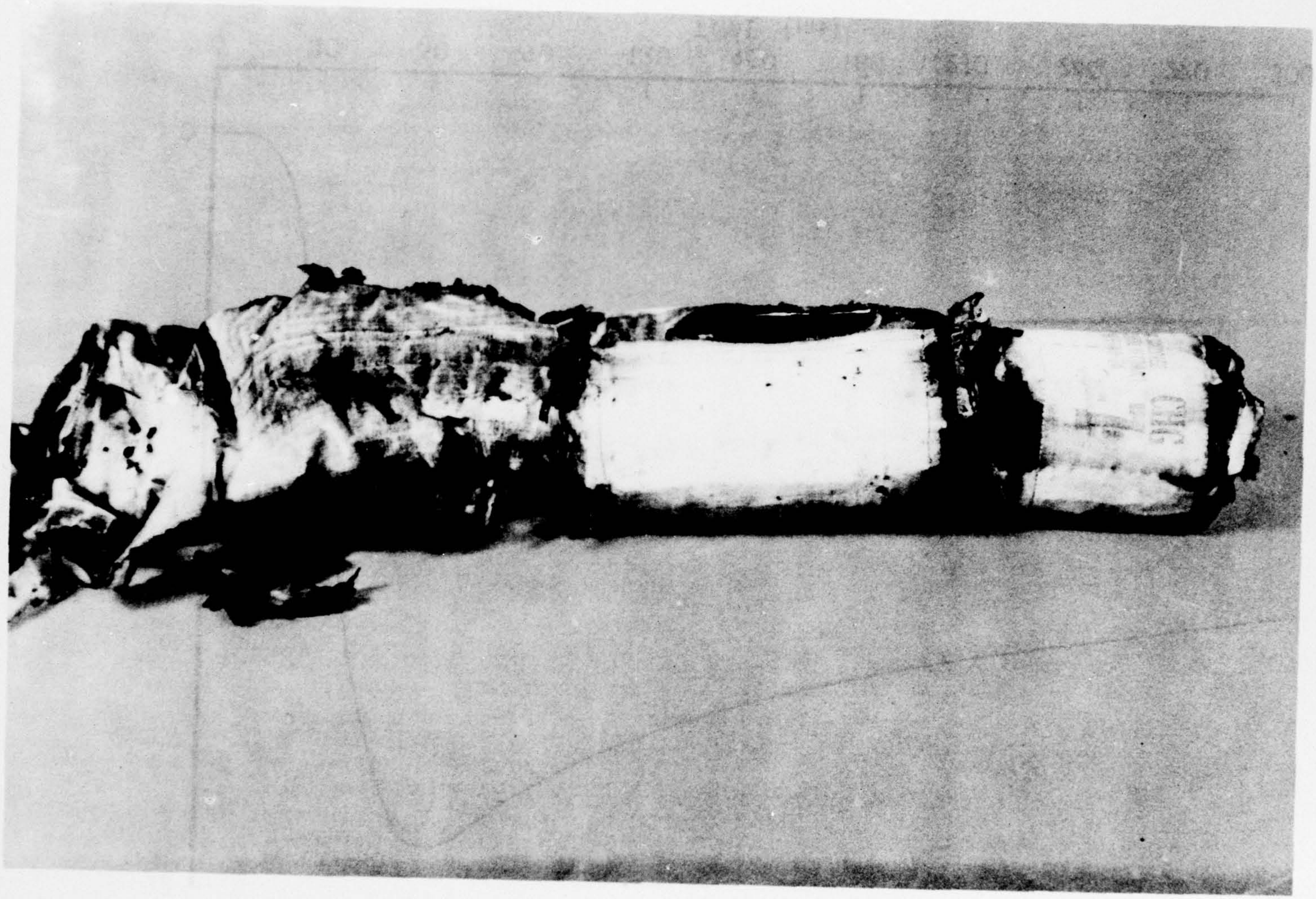

Figure 5. XM201E2 Charge After Ignition With Clean Burning Igniter

Figure 6. XM201E2 Charge After Ignition With Black Powder

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1. J.A. Demaree, "155mm M185 Tube Wear Test of Charge Propelling XM201", Jefferson Proving Ground Test Report No. JPG-76-601, Jun 76.

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